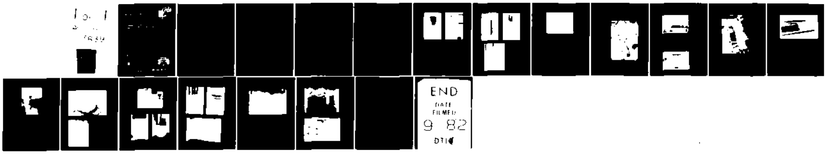
AD-A117 839 COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH F/G 4/2
SNOWPACK PROFILE ANALYSIS USING EXTRACTED THIN SECTIONS.(U)
MAY 82 W L HARRISON
UNCLASSIFIED CRREL-SR-82-11 NL



AD A117839

Special Report 82-11

Snowpack profile analysis using extracted thin sections

William L. Harrison

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Special Report 82-11

2. GOVT ACCESSION NO.: AD-A117839

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): SNOWPACK PROFILE ANALYSIS USING EXTRACTED THIN SECTIONS

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): William L. Harrison

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
U.S. Army Cold Regions Research and
Engineering Laboratory
Hanover, New Hampshire 03755

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
DA Project 4A762730AT42;
Task A; Work Unit 003

11. CONTROLLING OFFICE NAME AND ADDRESS:
Office of the Chief of Engineers
Washington, D.C. 20590

12. REPORT DATE: May 1982

13. NUMBER OF PAGES: 19

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report):
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18. SUPPLEMENTARY NOTES:

19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
Snow
Snowpack profiles

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

A method is presented for obtaining snow profiles for analysis. The method and required equipment replace former methods such as the "roaring bonfire" technique and the use of dyes.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

This report was prepared by Dr. William L. Harrison, Research Civil Engineer, of the Applied Research Branch, Experimental Engineering Divison, U.S. Army Cold Regions Research and Engineering Laboratory. Funding for this research was provided by DA Project 4A762730AT42, Design, Construction and Operations Technology in Cold Regions; Task A, Cold Regions Combat Operations Support; Work Unit 003, Battlefield Mobility. The manuscript of this report was technically reviewed by Dr. R.A. Liston and G.L. Blaisdell of CRREL.

The contents of this report are not to be used for advertising or promotional purposes. Citation of brand names does not constitute an official endorsement or approval of the use of such commercial products.

CONTENTS

ILLUSTRATIONS

SNOWPACK PROFILE ANALYSIS USING EXTRACTED THIN SECTIONS

William L. Harrison

INTRODUCTION

A useful practice in studies related to snow mechanics involves the observation and analysis of snowpack profiles. Several methods have been employed to highlight areas of interest such as stratification or deformations caused by external forces. Of these methods, the most common are the use of dyes sprayed on the profile (Kovacs 1976) and the "roaring bonfire" technique (Nakaya et al. 1936). In a recent extensive study of snow behavior under external loads (Harrison, in prep.), the bonfire technique was used rather than dyes because it produces the high contrast desirable for black and white photographs. Both methods require the removal of large volumes of snow; the time and physical effort required is considerable.

Other complicating factors experienced when using the bonfire technique are solar exposure, wind direction and curing time. If the section is cut so that the profile is exposed to the sun, the dark etchings caused by the bonfire will rapidly decay through melting. The exposure orientation is controlled by the wind direction. The bonfire technique requires that the wind direction be perpendicular to the exposed profile, with the profile located on the windward side of the excavation. Since wind is the controlling factor, the solar effect can be a problem. If the profile is to be cut through the snowpack where an external load has caused compaction, it is best to cut the profile immediately after the compaction has occurred. The compacted area tends to harden in a relatively short time, and it will be difficult to make the cut smoothly. On the other hand, if the profile is allowed to "cure" for 10-15 minutes after exposure, it will "burn" better. The grain structure changes in the disturbed area, and the compacted pattern becomes more discernible.

The daily experience with these factors over several months of winter research gave birth to the development of the thin section technique described in the following pages.

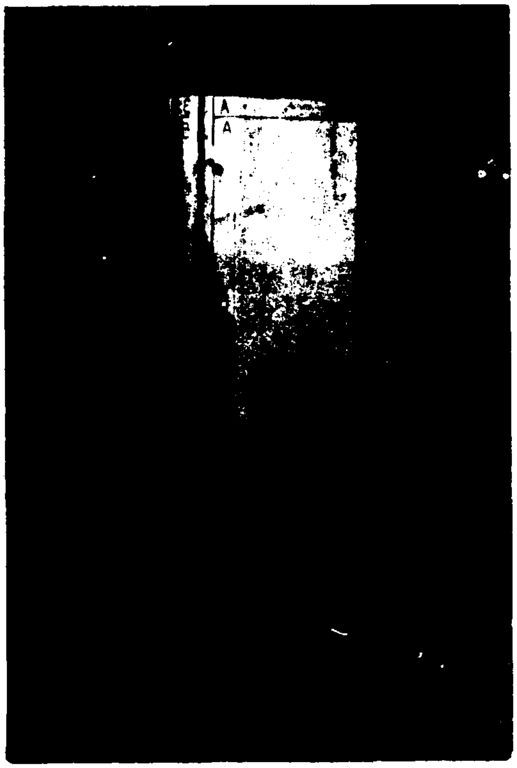


Figure 1. Snow sample tube prepared for collecting samples.

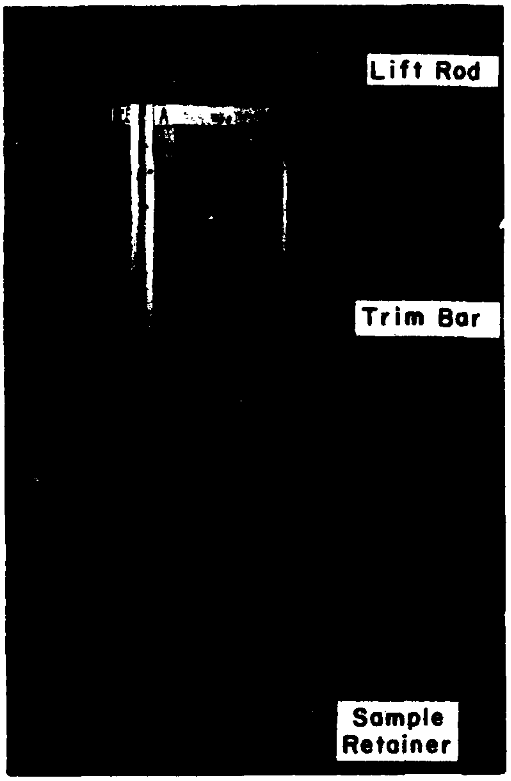


Figure 2. Sample tube mainframe.

THE SAMPLING DEVICE

The device described here is in the second generation of development, and although it produces adequate results, the hardware could be improved. The major components of the apparatus for viewing thin sections are a snow sample tube, a sample tube guide, a light table and camera stand, and two saws.

Snow sample tube

The dimensions of the tube assembly (Fig. 1) are 1235 mm x 156 mm x 358 mm. The mainframe consists of the sample cutter and retainer, trim bars, and lift rods (Fig. 2). The retainer plates are positioned in the recessed part of the retainer during entry and are activated inward by the lift rods prior to extracting the bulk sample (Fig. 3). There are three removable channels that can be attached to the frame (Fig. 4). The two aluminum channels retain the bulk sample during collecting, while the plexiglass channel retains the sample after trimming. The trim bars govern the sample thickness as well as the overall length of sample to be

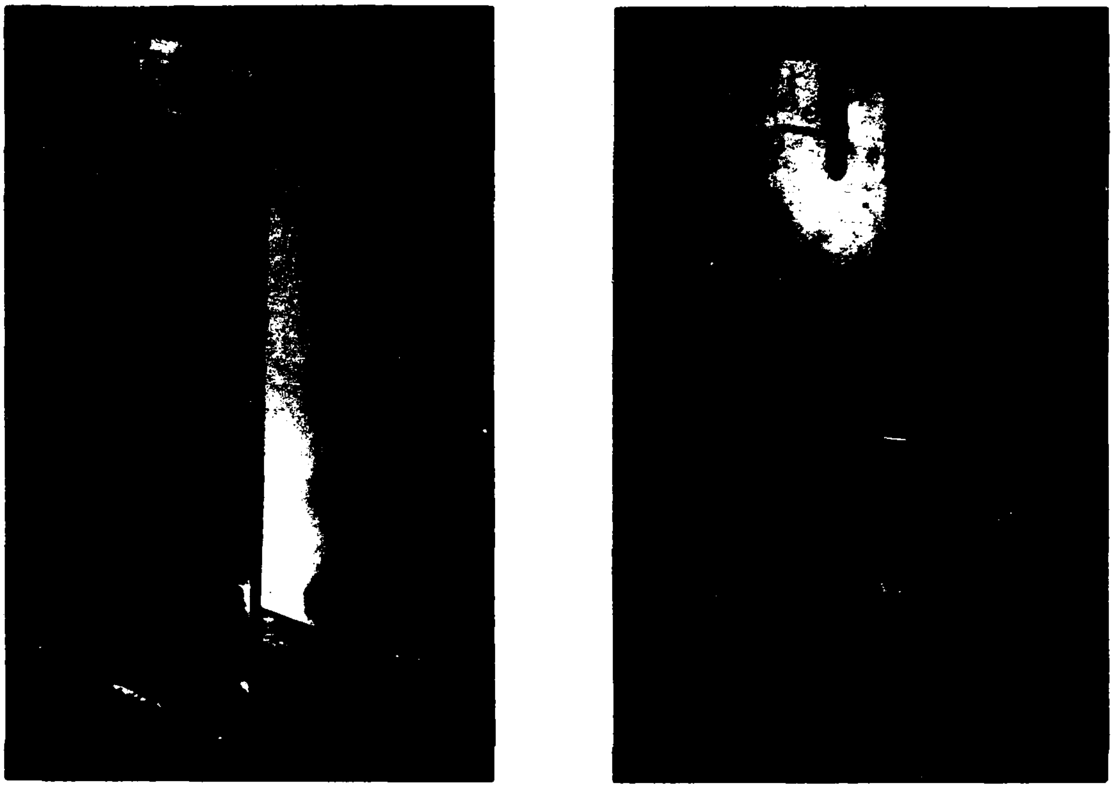


Figure 3. Sample retainer plates.

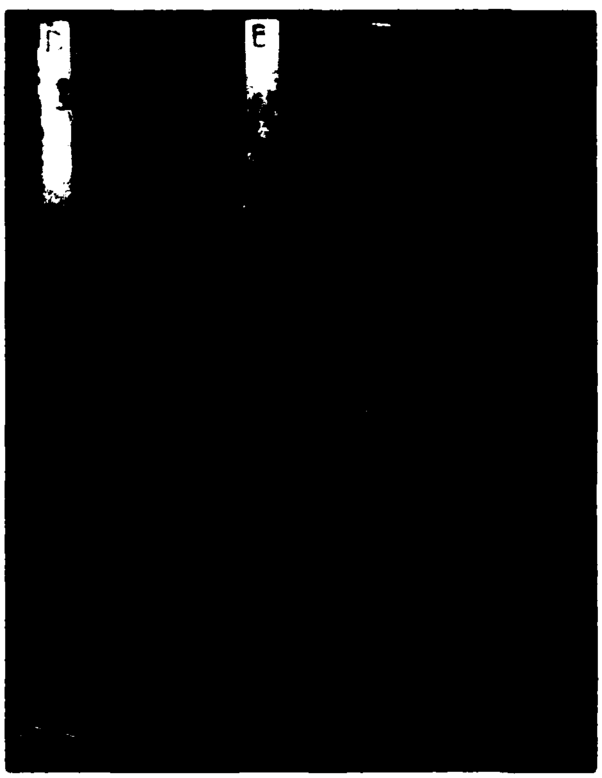


Figure 4. Channels.

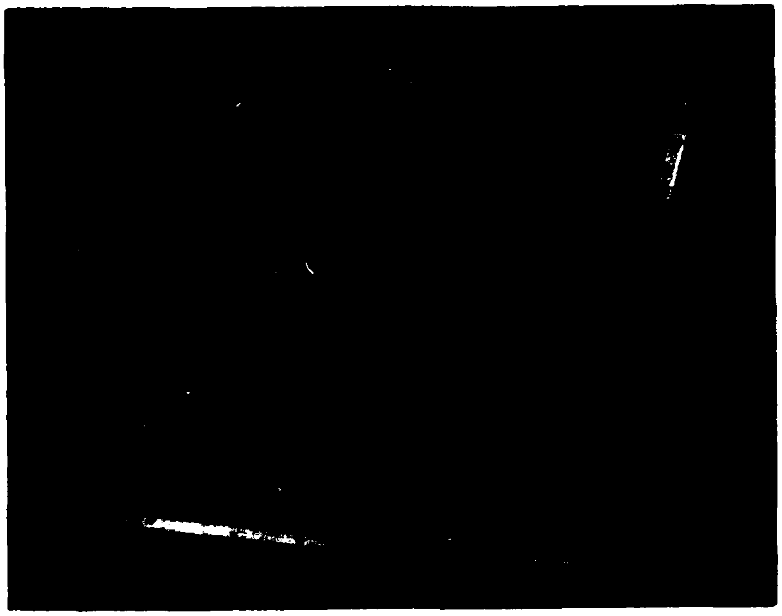


Figure 5. Sample tube guide and saw guides.

obtained; the bars used in this assembly provide a maximum sample length of 1 m and a thickness of 38 mm.

Sample tube guide

The sample tube guide (Fig. 5) serves two purposes: to serve as a guide for assuring vertical insertion of the snow sample tube and to prepare the bulk sample by serving as a template for sawing the perimeter of the in-situ bulk sample (Fig. 6). The trim bars fit into slots in the edges of the sample tube guide to maintain vertical alignment during insertion. Figure 6 shows the guide secured in position with a C clamp in the mobile field laboratory. The guide was designed to fit between the rails bordering the opening in the lab floor, which is used for access to the snowpack. When used in the open field, a large sheet of 3/4-inch plywood provides a stable base. The guide is placed over a hole in the center of the plywood and is steadied by a placement frame.

Light table and camera stand

The light table consists of a rectangular box with a 965- x 370-mm diffused glass plate mounted in one face (Fig. 7). The camera stand is a tubular frame that can be moved along the light table for selective photography. The light source is an AC-DC globe strobe light, which is placed in the box below the glass plate.

Figure 6. Bulk sample preparation.

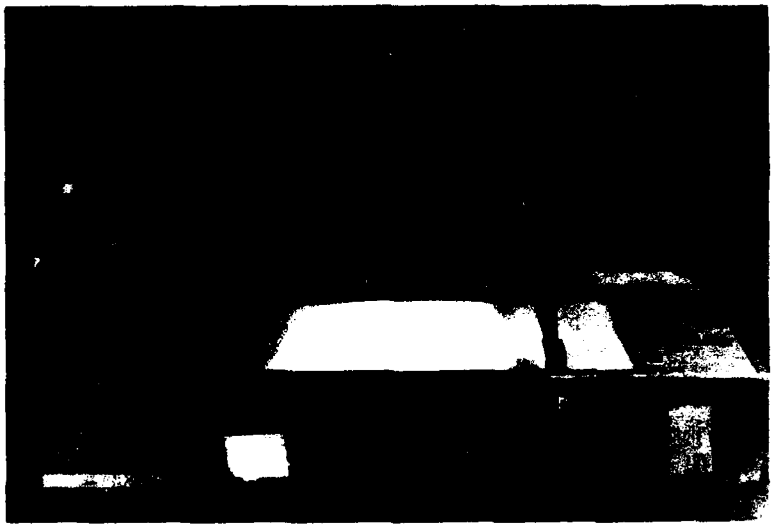


Figure 7. Light table and camera stand.

Saws

Two saws are used in the sampling process (Fig. 8). The first is a one-man crosscut saw normally used for cutting timber. The usable blade length is 1 m. This saw is used in the tube guide to prepare the perimeter of the sample before the tube is inserted. The second saw is a standard lumber crosscut saw (650-mm blade length) with the tooth-set removed. It is used to trim excess snow from the bulk sample to form the thin sample.

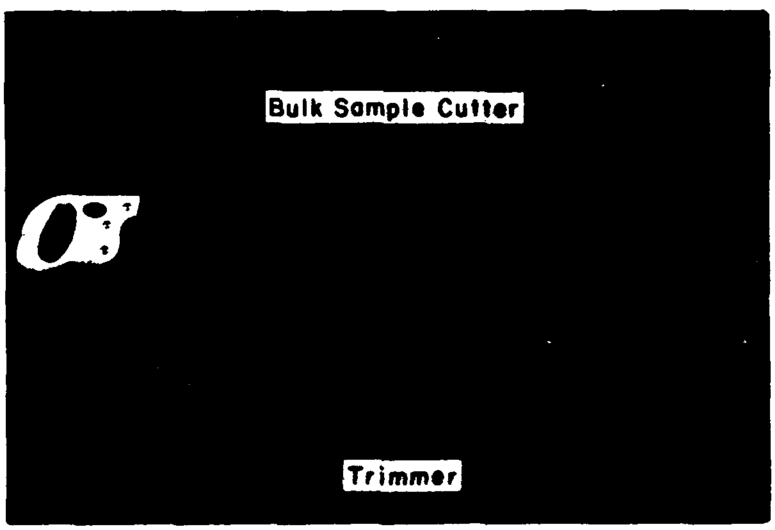


Figure 8. Saws.

Figure 9. Trimming the sample.

SAMPLING PROCESS

When the site has been selected and the sample tube guide secured, the bulk sample is cut by placing the saw guides alternately in the proper slots and cutting along the sample perimeter (Fig. 6). After the saw guides are removed and the sample tube is inserted to the desired depth, the sample retainer plates are activated by twisting the lift rods inward, closing off the bottom of the sample tube. The bulk sample that has been captured in the sample tube is lifted from the sample tube guide, and with

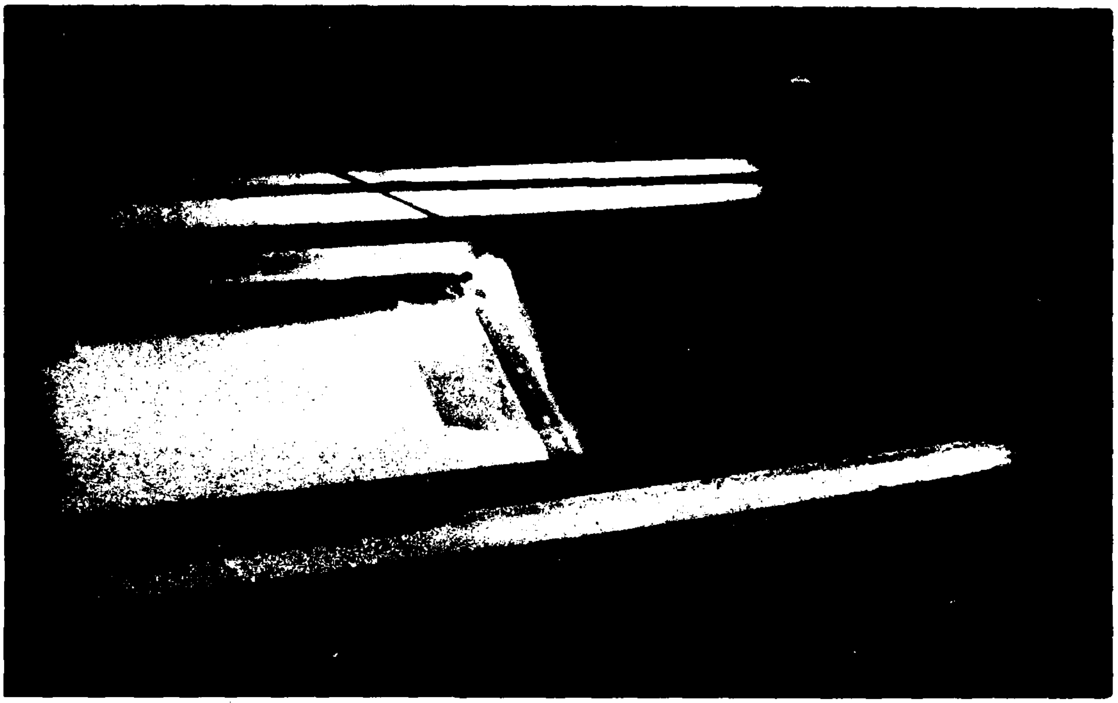


Figure 10. Illumination of a thin sample.

the tube resting on a firm surface in a tilted position, one aluminum channel is removed. The trimming saw is used along the trim bar to remove excess snow from the bulk sample (Fig. 9). The plexiglass channel is attached to the trim bar to replace the aluminum channel. The tube is then tilted in the opposite direction, the remaining aluminum channel is removed, and the other side is trimmed. The mainframe is then placed on the light table for photographing (Fig. 10). To take density or temperature profiles, only one channel need be removed, and measurements are taken immediately from the bulk sample.

DISCUSSION

The following discussion and figures are presented to indicate the quality of profile observations that can be made with the bonfire and thin sample techniques. The photographs illustrate that nothing is lost with the thin sample technique, and probably the results are finer in definition. In terms of time and manpower expended, the thin section sampler has been a significant improvement over past methods.

Figure 11. Profile observations and measurements.

Some examples of the bonfire method are shown in Figures 11-14. Figure 11 shows the volume of snow removed to expose 12 profiles of force-sinkage tests. The tests were performed in repetitions of two: one profile for etching and one profile for temperature profiles, density analyses, etc. (Fig. 12). Figure 13 is a close-up of the results from a force-sinkage test. Figure 14 shows the profile of a pressure bulb made by the passing of a tracked vehicle.

Figures 15-22 are thin section profiles. Figures 15-17 are the results of force-sinkage tests. The impressions in Figures 15 and 16 were made with the force applied from the surface down, while Figure 17 is the result of the force-sinkage impression made parallel to the snow layers. Figure 15 shows the high degree of stratification in the profile sample, while Figure 16 shows a profile representing a single layer from an extended storm. The free-form pattern in Figure 17 shows that flow will occur in areas of least resistance, in this case where the layers had weak

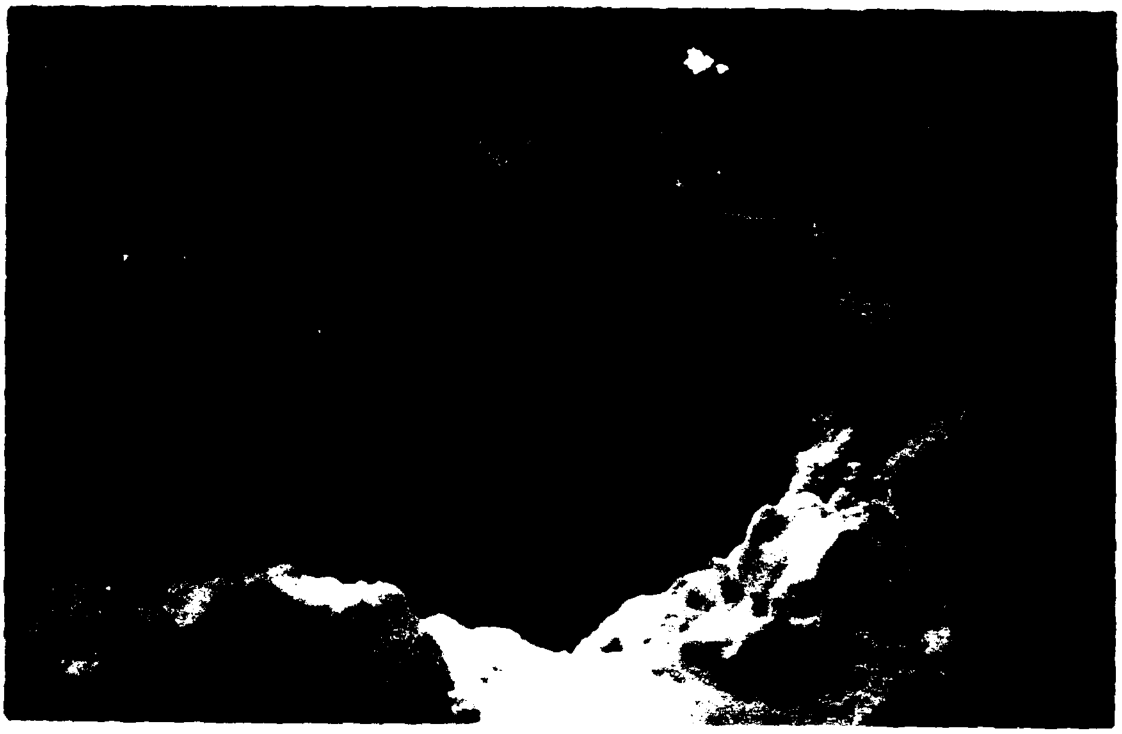


Figure 12. Profile etching with the bonfire technique.

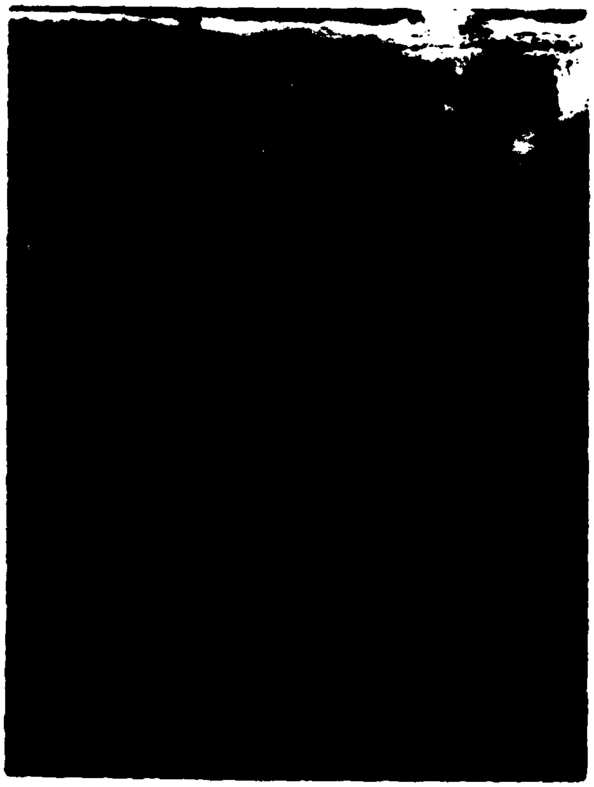


Figure 13. Force-sinkage test profile made with bonfire technique.

Figure 14. Snowpack profile made with the bonfire technique showing tracked vehicle pressure-bulb.

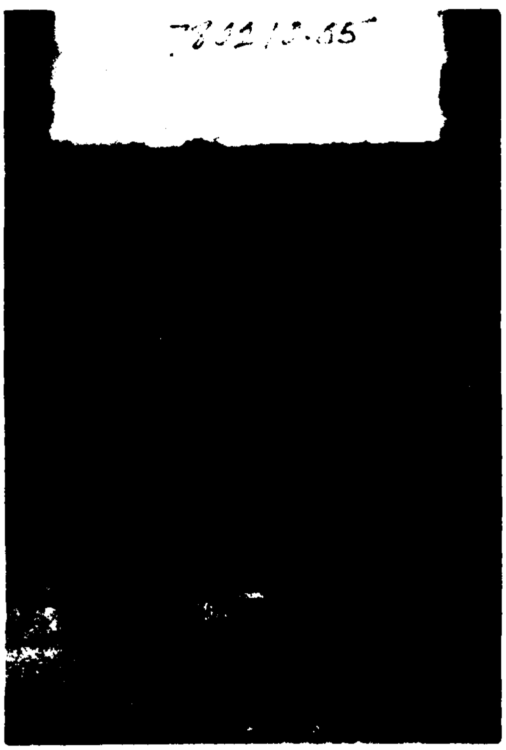


Figure 15. Force-sinkage test results in a highly stratified snowpack.

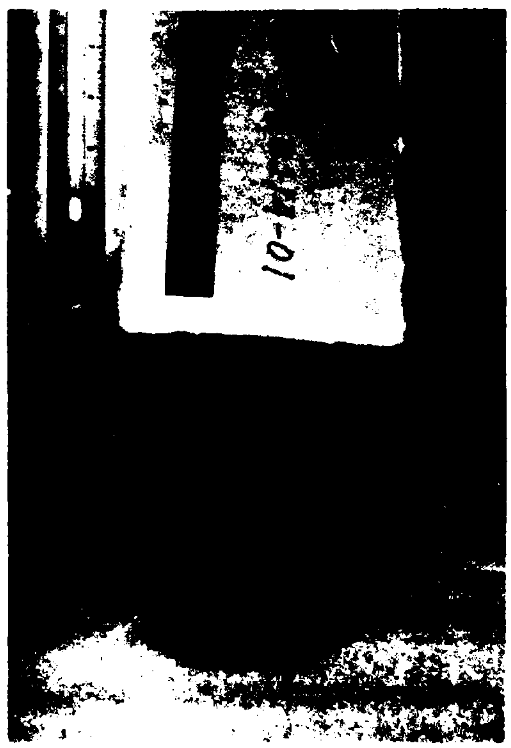


Figure 16. Force-sinkage test results in a uniform snowpack.

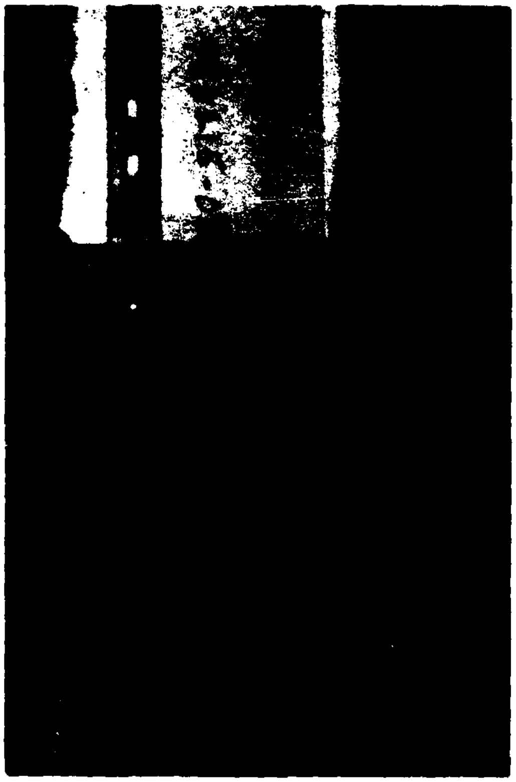


Figure 17. Force-sinkage test results conducted in direction of layers.

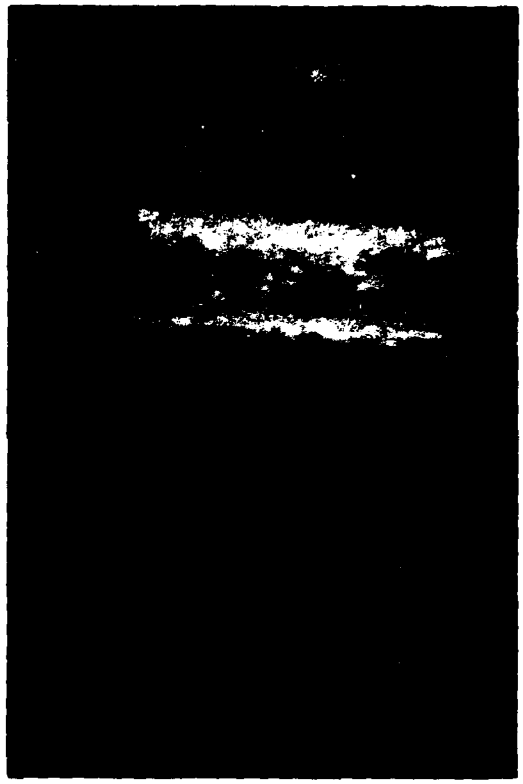


Figure 18. Undisturbed snowpack profile.

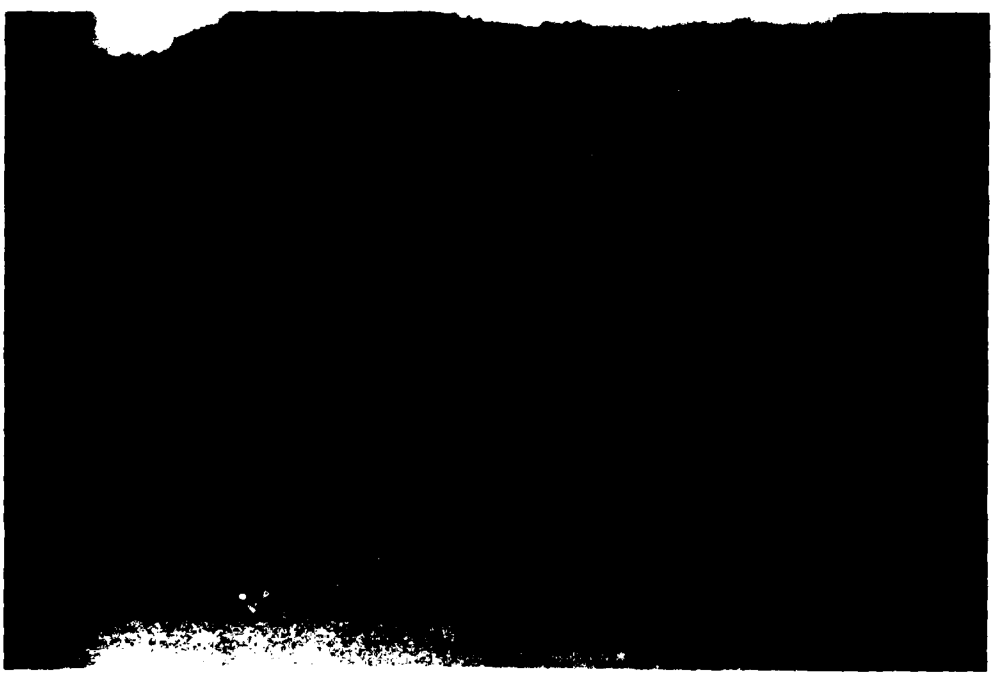


Figure 19. Observation of rupture patterns; IMP at low track slip.

Figure 20. Observation of rupture patterns; IMP at moderate track slip.

sections. Figure 18 is a profile of an undisturbed section of the snowpack after three closely spaced storms. The thin, light-shaded layer near the bottom of the figure is soft ice, while the light bands at the center are very wet snow. Above the bands of wet snow is a very dark band that was, in fact, brown. This was the result of high winds lifting dust particles from the desert nearby and depositing them with the snowfall.

Figures 19-22 are transverse profiles (thin sections in the direction of vehicle motion) of ruts left by tracked vehicles having different cleat arrangements. The track that caused the rupture patterns in Figures 19 and 20 had 2-inch cleats, 20 inches on center, with 4 one-inch-square tubes spaced equally between the cleats (every 4 inches). The rupture pattern shown in Figure 19 was produced by low slip, while the rupture pattern in Figure 20 was caused by moderate track slip. The rupture patterns in Figures 21 and 22 were made by a track having 2-inch cleats spaced at 4 inches on center. Figure 22 shows the results at low slip and Figure 22 at high slip.

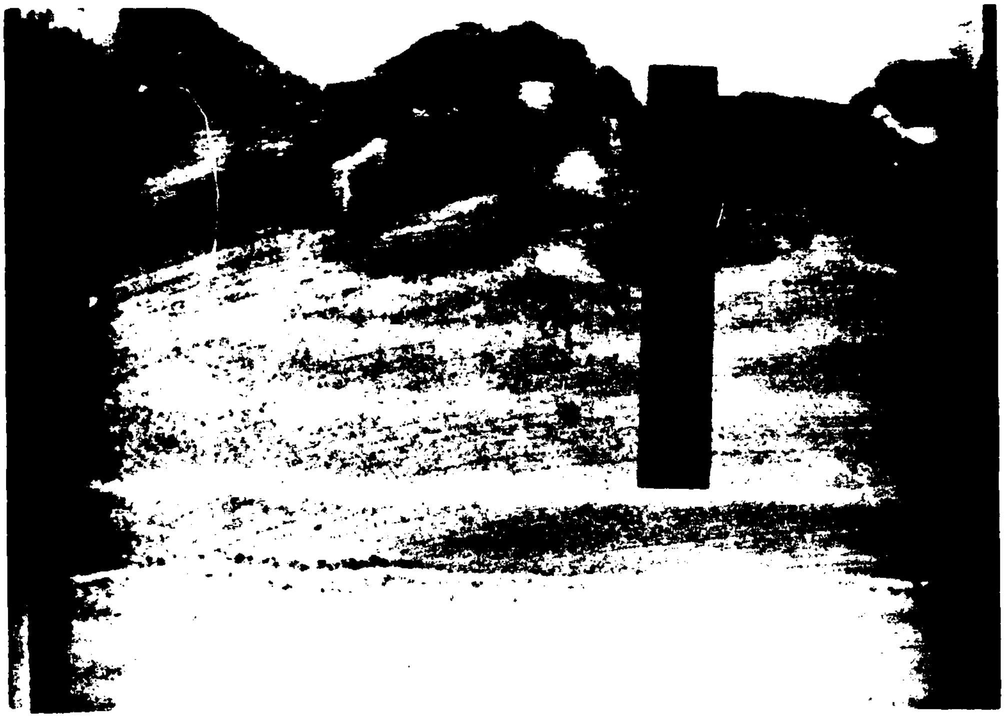


Figure 21. Observation of rupture patterns; super IMP (1450 series) at low track slip.

Figure 22. Observation of rupture patterns; super IMP (1450 series) at moderate track slip.

CONCLUSIONS

The thin section technique is a suitable substitute for the bonfire and dye techniques for analyzing snowpack profiles. The results are obtained with less expenditure of time and physical effort, and the end product is, in some cases, of higher quality.

LITERATURE CITED

Kovacs, A. (1976) Study of piles installed in polar snow. CRREL Report 76-23.

Nakaya, U., M. Tada, Y. Sekido and T. Takano (1936) The physics of skiing, the preliminary and general survey. Investigations on snow, no. 9. Journal of the Faculty of Science, Hokkaido Imperial University, series II, vol. 1, p. 265-287.

Harrison, W.L. (In preparation) Snow failure under external loads. CRREL Report.

DATE
ILMED
8